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second also disappeared. There was no projection of the star on the moon's surface; but it appeared to assume a planetary disc, part of which was hidden, and the rest remained as a slight excrescence on the moon's edge. Probably, had the immersion taken place at the dark limb, the whole of the spurious disc would have been seen projected on the surface, as the impression produced on my mind was that such was now the case, only the bright surfaces of the moon and star could not be distinguished from one another.

"In consequence of the moon's position being low in the east, the line joining the stars formed nearly a right angle with a tangent to the moon's disc; so that the longest possible time elapsed between the immersions: and the fact that the stars passed behind a very small portion of the moon's body, so that they might at first do little more than graze the edge, throws some light on the unusual period of time during which the attachment continued.

"The telescope was my equatoreal by Ross, 4 feet focal length, $3\frac{3}{8}$ inches aperture. Power, 173."

On the Dimensions of the Rings of Saturn.

By the Rev. R. Main, M.A.

The author commences by stating, that in the winter of 1852–3 he executed a series of measures of the dimensions of the rings of *Saturn*, with a double-image micrometer, similar in principle, but not identically the same, as that used in the measures which he executed in 1849 for determining the form of the planet, an account of which is published in vol. xviii. of the *Memoirs* of the Society. In the beginning of 1854 he repeated his measures of the dimensions of the rings. Both sets of measures will be found printed and reduced in the volumes of the *Greenwich Observations* for 1852 and 1854, which also contain an account of the construction of the micrometer, the method of using it, the degree of accuracy and delicacy of measurement attainable by it, and other circumstances which a critic would desire to become acquainted with.

The author, in giving a synopsis of the results of his measures as inserted in the *Greenwich Observations*, remarks, that he attaches no great weight to the measures of the breadth of the black division, on account of the extreme difficulty and uncertainty of the contacts of the point of reference with its borders. In fact, the aperture of the object-glass being only $6\frac{3}{4}$ inches, and only half of the light of the planet being employed for the formation of each image, all the measures were very difficult from the uncertainty of determining the exact contact of the assumed point of reference, namely, the extreme edge of the exterior bright ring, with the borders of the inner ring, and of the ball whose

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dimensions were required. This difficulty was much increased by the confusion arising from the superposition of the different portions of one of the images upon the other, which obliged the author to deviate from the usual method of making contacts of images on opposite sides on account of its impracticability. He has consequently given in his synopsis of results only the position of the centre of the black division.

The author's measures for 1852–3 are included between December 30, 1852, and February 19, 1853. The following is the mean for January 11, 1853:—

Distance of assumed centre from	″
East exterior edge of outer ring	21·36
— centre of black division	19·19
— interior edge of inner bright ring	14·52
— edge of ball	8·79
West edge of ball	9·06
— interior edge of inner bright ring	14·50
— centre of black division	18·62
— exterior edge of outer ring	21·64

Or, assuming with M. Otto Struve that the centre of the ball of *Saturn* is coincident with that of the rings, we have, by taking the means of the measures on the east and west sides of the planet, the following results for 1853, January 11, when the log. distance of *Saturn* from the earth was 0·94267:—

Distance of centre of planet from	″
Edge of ball	8·98
Interior edge of inner bright ring	14·51
Centre of black division	18·91
Exterior edge of outer bright ring	21·50

Hence, subtracting the semi-diameter of the ball from the other quantities, and calling the distances of the edge of the ball from each of the other measured parts in order, according to M. Struve's notation, *ad*, *ae′*,[*] and *ag*, we have,—

$$ad = 5''\cdot53 \qquad ae' = 9''\cdot93 \qquad ag = 12''\cdot52$$

Or, reducing these results to those which would have been observed at the mean distance of the planet 9·5389 (or $\log.^{-1}\,0\cdot97950$), assumed by M. Struve, the measures are,—

$$ad = 5''\cdot08 \qquad ae' = 9''\cdot12 \qquad ag = 11''\cdot50$$

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[*] *ae′* is the mean of *ae* and *af* in M. Struve's figure.

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The observations of 1854 extend from February 2 to March 17; the following is the mean value of the results for the epoch February 23, 1854:—

Distance of assumed centre from

	″
East exterior edge of outer ring	20·62
— centre of black division	17·44
— interior edge of inner bright ring	13·75
— ball	8·01
West edge of ball	8·66
— interior edge of inner bright ring	14·27
— centre of black division	18·29
— exterior edge of outer ring	20·59

The means of the measures given above correspond to the log. distance of the planet 0·96236, and at this distance we have, therefore (taking the means on each side of the centre as before),—

Distance of centre of planet from

Edge of ball = 8″·34 (semi-diameter of ball)
Interior edge of inner bright ring = 14·01
Centre of black division = 17·87
Exterior edge of outer bright ring = 20·61

Hence, at this distance, $ad = 5''{\cdot}67$, $ae' = 9''{\cdot}53$, $ag = 12''{\cdot}27$. And at the mean distance of the planet, 9·5389,—

$$ad = 5''{\cdot}46 \qquad ae' = 9''{\cdot}17 \qquad ag = 11''{\cdot}81$$

Hence the general results of the measures, compared with the measures of M. Struve, are the following:—

	Main. 1852–3.	Main. 1854.	Struve.
	″	″	″
ad =	5·08	5·46	3·65
ae' =	9·12	9·17	8·52
ag =	11·50	11·07	11·07

Or, taking the mean of the two sets of measures, since they have on the whole pretty nearly equal weights,—

	Main. 1852–3.	Struve. 1854.	M–S.
	″	″	″
ad =	5·27	3·65	+ 1·62
ae' =	9·15	8·52	+ 0·63
=	11·28	11·07	+ 0·21

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With regard to these results, the author remarks that the differences increase rapidly on approaching towards the limb of the ball from which they are reckoned, and seem to indicate that, either by M. Otto Struve or by himself, large arcs are measured on a different scale from small ones.

The author remarks that, so far as his measures can be depended on, they do not give any support to the hypothesis of Otto Struve, concerning the gradual diminution of the interval between the ball of the planet and the inner edge of the interior bright ring; and if there were no discrepancies in the measures which made him diffident of presenting them to astronomers as capable of settling a point of so much delicacy, he should be fully satisfied that M. Struve's idea was not yet sufficiently proved. He was fully convinced, however, of the uncertainty of many of the individual measures from the confusion of the images, and of their consequent inferiority to those made for the determination of the form of the planet in 1849, and also to the measures for determining the length and breadth of the exterior edge of the outer ring. But what more especially impressed him with the necessity of receiving the results with caution, was the circumstance that the final measure for the ball of the planet is considerably smaller than that which he deduced in 1849, and which agrees with the value generally adopted by astronomers.

Taking the means of the east and west semi-diameters of the ball as measured in 1852–53, and reducing them to the mean distance assumed by M. Otto Struve, namely, 9·5389, the author obtains 8″·20 for the final value of the semi-diameter of the ball.

Treating the measures of 1854 in the same way, he finds the resulting value of the semi-diameter to be 8″·02. He remarks that the agreement between this result and that deduced from the measures of 1852–3, is sufficiently close to show that they are a fair representation of observations of the ball made by his own eye with the double-image micrometer, and in the manner previously explained when the ball was seen surrounded by his ring. The mean of the two results above mentioned (8″·20 and 8″·02), when compared with the corresponding value of the semi-diameter deduced by him in 1849, namely, 8″·75, indicates a difference of no less than 0″·64; a quantity certainly too great to be the result of accident, and undoubtedly attributable to the different circumstances under which the measures were made. M. Struve's value of the semi-diameter of the ball is 8″·80, a result agreeing almost exactly with that deduced by the author in 1849.

The author next proceeds to give his measures of the extreme length and breadth of the exterior edge of the outer ring. He remarks that these measures are much superior in accuracy to the others, the outer edges of the system of rings presenting no impediment to the ordinary use of the double-image micrometer. The mean of the measures made in 1852–3 gives 39″·67 for the diameter of the exterior ring; the mean of the measures made in

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1854 gives 39″·76; consequently the mean of the entire collection of measures is 39″·72.

The author also deduces from the measures of the minor axis of the exterior ring the corresponding values of the major axis, by taking into account the elevation of the earth above the plane of the ring. The mean value of the diameter of the ring thus found is 39″·75, agreeing almost exactly with that determined by direct observation. This result the author considers to be definitive, and comparable with the value of the semi-diameter of the ball obtained by him in 1849.

Having thus given the general results of the measures of the rings, the author proceeds to examine the ratio which the dark space intervening between the inner bright ring and the planet bears to the breadth of the bright rings. It has been mentioned that he found the breadth of the dark space to be 5″·27, and that of the bright rings to be 6″·01; consequently the ratio of the two quantities is 0·87. On the other hand, M. Otto Struve found the breadth of the dark space to be 3″·65, and that of the rings 7″·42, which give a ratio of only 0·49.

The difference between the values of the ratio thus found being too great to be passed over without any attempt at explanation, the author proceeds to substantiate his own measures by other considerations. He had already alluded to the difficulty of making accurate contacts for the interior edge of the inner ring and the ball, on account of the confusion of the images. The difficulty was very much greater when the object of reference was beyond the centre than when it was near the outer edge of the system of rings, and the measures would consequently be less accurate. From fresh trials, which he made during the present opposition of the planet (December 1855), he felt convinced that at the *entering* side of the point of reference the measures can be made with confidence, but cannot be executed so unexceptionably on the other side. He therefore discusses the two sets of measures separately.

The measures of 1852–3 give him 0·95 for the ratio of the dark space to the breadth of the rings; the measures of 1854 indicate the same ratio to be 0·97. A curious circumstance, however, connected with both sets of measures, is this,—in several instances the breadth of the bright rings is conspicuously less than the dark interval, and the difference between them steadily decreases till the two are equal; then the breadth of ring becomes greater than the dark interval, and their ratio steadily increases. This curious law, developed equally well in both sets of observations, can scarcely be the result of accident. It probably depends on the change of optical appearance of the planet during the period of observation, and perhaps in some degree, also, on the training of the eye of the observer during the time. The author adds, however, that it would be a very bold assumption if, on the strength of these observations, which are incomparably better than the early observations on which M. Struve rests his

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theory, we were to conclude that the system of *Saturn* really underwent periodical changes of the magnitude thus indicated.

The author was fortunately enabled to avail himself of some favourable evenings during the present opposition (December 1855) to make an extensive series of observations, with direct reference to the relation of the breadth of the system of bright rings to that of the dark interval.

A numerous series of measures, executed on the evening of the 5th of December, gave him 1·08 for the ratio of the dark space to the breadth of ring; a similar series of measures, executed on the 6th, gave him 1·11 for the value of the same ratio. It has been mentioned that the values of the semi-diameter of the planet which the author obtained from his recent observations, are sensibly smaller than the value of the same element which he deduced in 1849, during the disappearance of the ring. He remarks that this probably arises from the glare of the ring, which prevents the true border of the planet being observed. The circumstance at all events suggests a correction which must be applied to the observed values of the dark space between the planet and the bright rings. The author here appends a table, by which he shows that the application of this correction causes the disappearance of the curious anomaly in the ratios between the values of the dark space and the breadth of the rings. The following are the final results deduced by him from the observations of 1852–3,—

$$\frac{\text{Corrected breadth of dark space}}{\text{Breadth of rings}} = 0{\cdot}838$$

and from the observations of 1854,—

$$\frac{\text{Corrected breadth of dark space}}{\text{Breadth of rings}} = 0{\cdot}844$$

The agreement of these results leaves nothing to be desired. We have then the following definitive values for the mean distance of the planet from the earth previously assumed,—

Diameter of exterior edge of outer ring = 39″·73
Diameter of inner edge of inner ring = 27·65
Equatoreal diameter of ball = 17·50

The author next examines the question relative to the dimensions of the black division. His final conclusion is, that the diameter of the circle coinciding with the centre of the division amounts to 36″·15.

He remarks, that there is still one circumstance connected with the observations of the planet which does not at present admit of explanation. Each of the results of the present year is quite equal in weight to either of the results deduced from the totality of the observations of 1853 and 1854; the two results agree

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with each other with all desirable accuracy; and yet the ratios indicated by them are very much greater than those of 1853 and 1854. He adds, that it would be useless to speculate at present upon the cause of this discordance; but he looks forward with interest to the observations which he hopes to make at the present opposition in the expectation of obtaining some solution of the difficulty. He concludes with the following remarks:—

"For the present, I can only express my opinion that the results which are given exhibit with tolerable accuracy the dimensions of the *Saturnian* system, and that no change whatever has taken place in the system since the time of Huygens. If this opinion be correct, it will follow that M. Struve's measures of the breadth of the dark space between the bright rings and the ball have been influenced by some circumstance which has not affected the distance between the ball and the outer edge of the outer ring, for in this latter particular my measures are almost coincident with his. Under these circumstances there is little doubt that M. Struve will be anxious to seize the favourable opportunity that presents itself at the present opposition of the planet for repeating his measures in a way that will prevent the possibility of doubt; and I may at the same time direct the attention of such English astronomers as are furnished with good telescopes equatoreally mounted to the interesting circumstances which I have attempted in the present memoir to elucidate."

On the Attraction of the Himalaya Mountains and of the elevated Regions beyond them, upon the Plumb-line in India. By the Venerable John Henry Pratt, M.A., Archdeacon of Calcutta.*

The author of this paper commences by remarking that the results of the measurement of the great arc of the meridian of India afford undoubted indications of the disturbing influence exercised upon the direction of the plumb-line by the attraction of the Himalaya Mountains and the elevated regions lying beyond them. Thus, the amplitude of the northern division of the arc included between Kaliana and Kalianpur, when determined by astronomical observations of latitude at the two extreme stations, was found to be 5° 23′ 37″·058; whereas, when computed geodetically, assuming the usually admitted values of the major axis and ellipticity of the earth, the value of the amplitude appeared to be 5° 23′ 42″·294. The circumstance of the astronomical arc being in *defect* as compared with the geodetical arc, is favourable to the supposition of the discordance being due to the attraction of the mountainous country situate to the north of the arc; for the ten-

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* Phil. Trans., 1855, p. 53, *et seq.*